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Title: **PICTURE SIGNAL TRANSMITTING METHOD AND APPARATUS**

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PICTURE SIGNAL TRANSMITTING METHOD AND APPARATUS

RELATED APPLICATION

This is a continuation-in-part of U.S. Patent
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Application 08/219,472, filed March 29, 1994.

BACKGROUND OF THE INVENTION

The present invention relates to coding and decoding of
a picture signal for transmission, and, more particularly, is
directed to matching the type of predictive coding applied to
pictures of the picture signal.

In, for example, a teleconferencing system or a video
telephone system, moving picture signals are compressed and
encoded by taking advantage of intra-frame and inter-frame
correlation so that they can be more efficiently transmitted over
a communication channel to a remote location.

Intra-frame correlation can be utilized by an
orthogonal transformation, such as a discrete cosine
transformation (DCT).

Inter-frame correlation can be utilized by predictive
encoding between successive pictures. As used herein, a picture
generally refers to an image represented by a frame. When the
fields of a frame are coded in a non-interlaced manner, that is,
separately, each field may be referred to as a picture.

As shown in Fig. 1A, for example, frame pictures PC1,
PC2 and PC3 are generated at time points t1, t2 and t3. As shown
by shading in Fig. 1B, the difference between the frame pictures

PC1 and PC2 is obtained as difference picture data PC12, and the difference between the frame pictures PC2 and PC3 is obtained as difference picture data PC23. Since there is a fairly small change between signals of temporally neighboring frames,

5   transmission of only the difference picture data utilizes the transmission channel more efficiently than transmission of the original pictures. That is, using the difference picture data as encoded picture signals reduces the amount of data to be transmitted.

10   However, if only the difference signals are transmitted, the original picture cannot be restored. It is advantageous to occasionally transmit a picture which is not predictively encoded as a reference for difference picture data, and because it is sometimes more efficient than transmitting the

15   picture as a predictively encoded picture.

Pictures which are encoded utilizing only intra-frame correlation and not inter-frame correlation, are referred to herein as intra-pictures or I-pictures.

Pictures which are encoded with predictive encoding

20   relative to one previously encoded picture are referred to herein as predictive pictures or P-pictures. The previously encoded picture may be an I-picture or a P-picture, and temporally succeeds the P-picture.

Pictures which are encoded with predictive encoding

25   relative to at most two pictures, a temporally preceding and a

temporally succeeding picture, are referred to herein as bi-directionally predictive coded pictures or B-pictures. The two pictures may each be an I-picture or a P-picture. When both are used, the mean value of the two pictures is obtained and used as

5 a reference picture for the picture to be encoded.

A series of pictures may be considered as groups of pictures having a predetermined number of frames such as F1 ... F17. The luminance and chrominance picture signals of the leading frame F1 are encoded as an I-picture, the picture signals

10 of the second frame F2 are encoded as a B-picture, and the picture signals of the third frame F3 are encoded as a P-picture. The fourth and the following frames F4 to F17 are encoded alternately as B-pictures and P-pictures. Fig. 2A shows the reference pictures used for encoding P-pictures, while Fig. 2B

15 shows the reference pictures used for encoding B-pictures.

As shown in Figs. 3A and 3B, there are four methods for encoding the macro-blocks (discussed below) of a picture. When multiple methods are suitable, the method which will give the smallest amount of encoded data is employed on a macro-block by

20 macro-block basis. Blocks F1 to F5 in Fig. 3A represent data for frames of moving picture signals, whereas blocks F1X to F5X in Fig. 3B represent data for encoded frames. The solid line arrows in Fig. 3A show the frames to which motion vectors x1 ... x6 relate.

The first method, shown as SP1, is to not use predictive encoding, that is, to use only intra-frame correlation. This is suitable for any macro-blocks of an I-picture, a P-picture and a B-picture. In other words, if less

5   encoded data is produced without predictive encoding, then this method is selected.

The second method, shown as SP2, is to predictively encode relative to a picture which temporally succeeds the current picture, referred to as backward predictive encoding.

10   The third method, shown as SP3, is to predictively encode relative to a picture which temporally precedes the current picture, referred to as forward predictive encoding. The second method is suitable for macro-blocks of only B-pictures. The third method is suitable for macro-blocks of P-pictures and B-

15   pictures.

The fourth method, shown as SP4, is to predictively encode relative to the mean value of two pictures, one temporally preceding and one temporally succeeding the current picture. This method is suitable for macro-blocks of only B-pictures.

20   The encoding sequence will now be described.

The first frame F1 is encoded as an I-picture using the first method SP1 so that it is directly transmitted over a transmission channel as encoded data F1X.

The third frame F3 is encoded as a P-picture. When the

25   third method SP3, forward predictive coding, is used for a macro-

block, difference signals from the temporally preceding frame F1 used as the reference picture, as indicated by a broken-line arrow SP3, and a motion vector x3 between the reference picture F1 and the current picture F3, are calculated and encoded as data

5   F3X for that macro-block. Alternatively, in this or another macro-block of the P picture, if a smaller amount of encoded data is produced for a macro-block of the P picture being encoded, the first method SP1 can be used wherein the data of the original frame F3 are directly utilized as the transmission data F3X for

10   that macro-block.

The second frame F2 is encoded as a B-picture.

When the fourth method SP4 is used to encode a macro-block of the frame F2, a difference between the mean value of the temporally preceding frame F1 and the temporally succeeding frame

15   F3 is calculated, on a pixel by pixel basis. The difference data and the motion vectors x1 and x2 are encoded as data F2X.

When the first processing method SP1 is used to encode a macro-block of the frame F2, the data of the original frame F2 forms the encoded data F2X.

20   When one of the second or third methods SP2, SP3 is used to encode a macro-block of the frame F2, one of the difference between the temporally succeeding frame F3 and the current frame F2, and the difference between the temporally preceding frame F1 and the current frame F2 is calculated. The

difference data and one of the motion vectors x1, x2 are encoded as the data F2X.

The frame F4 for the B-picture and the frame F5 for the P-picture are processed in a similar manner as described above to

5   generate transmitted data F4X and F5X.

Fig. 4 illustrates an arrangement for encoding and decoding moving picture signals in accordance with the above-described predictive encoding scheme. As shown in Fig. 4, an encoding device 1 encodes input picture signals and transmits the

10   encoded signals to a recording medium 3 as a transmission channel for recording. A decoding device 2 reproduces the signals recorded on the recording medium 3 and decodes these as output signals.

The encoding device 1 includes an input terminal 10, a

15   pre-processing circuit 11, A/D converters 12 and 13, a frame memory 14 including a luminance signal frame memory 15 and a color difference signal frame memory 16, a format converting circuit 17 and an encoder 18.

Input terminal 10 is adapted to receive a video signal

20   VD and to supply the signal VD to pre-processing circuit 11 which functions to separate the video signal VD into luminance signals and color signals, herein chrominance or color difference signals, that are applied to analog-to-digital (A/D) converters 12 and 13, respectively. The video signals, digitized by analog-

25   to-digital conversion by the A/D converters 12 and 13, are

supplied to frame memory 14 having memories 15, 16 which function to store the luminance signals and the color difference signals, respectively, and to read out the signals stored therein to format converting circuit 17.

5   The converter 17 is operative to convert frame format signals stored in the frame memory section 14 into block format signals. As shown in Fig. 5A, pictures are stored in the frame memory section 14 as frame-format data having V lines each consisting of H dots. The converting circuit 17 divides each

10   frame into N slices, each slice comprising a multiple of 16 lines. As shown, in Fig. 5B, the converter 17 divides each slice into M macro-blocks. As shown in Fig. 5C, each macro-block represents luminance signals Y corresponding to 16 × 16 pixels or dots, and associated chrominance Cr, Cb signals. These luminance

15   signals are sub-divided into blocks Y1 to Y4, each consisting of 8 × 8 dots. The 16 × 16 dot luminance signals are associated with 8 × 8 dot Cb signals and 8 × 8 dot Cr signals. The converter 17 is also operative to supply the block format signals to the encoder 18, which is described in detail below with

20   reference to Fig. 6.

          The encoder 18 operates to encode the block format signals and to supply the encoded signals as a bitstream over a transmission channel for recording on the recording medium 3.

          The decoding device 2 includes a decoder 31, a format

25   converting circuit 32, a frame memory section 33 including a

luminance signal frame memory 34 and a color difference signal

frame memory 35, digital-to-analog converters 36 and 37, a post-

processing circuit 38 and an output terminal 30.

The decoder 31 is operative to reproduce encoded data

5   from the recording medium 3 and to decode the encoded data, as

described in detail below with reference to Fig. 9, and to supply

decoded data signals to format converting circuit 32 which is

operative to convert the decoded data signals into frame format

data signals and to supply the frame format data signals as

10   luminance signals and color difference signals to the memory 33.

The memories 34, 35 of the memory 33 function to store the

luminance and chrominance signals, respectively, and to apply

these signals to D/A converters 36 and 37, respectively. The

analog signals from converters 36, 37 are synthesized by a post-

15   processing circuit 38 which functions to form output picture

signals and to output them to output terminal 30, and thence to a

display unit, such as a CRT, not shown, for display.

Fig. 6 illustrates the encoder 18 shown in Fig. 4.

Generally, the encoder 18 stores three pictures, the

20   current picture and the pictures temporally preceding and

succeeding the current picture. Based on the sequential position

of the current picture in the group of pictures, the picture

coding type (I, P or B) is selected for each picture. The

picture type sequence is determined by a user using picture type

input device 65, independent of the pictures applied to an input
terminal 49.

The encoder 18 also chooses one of frame-based and
field-based predictive encoding as will be explained with

5   reference to Fig. 7, and further chooses one of frame-based and
field-based DCT encoding as will be explained with reference to
Fig. 8. For each picture, appropriate motion vectors are
obtained and the picture is predictively encoded relative to
zero, one or two previously encoded pictures which have been

10   locally decoded and which are referred to as reference pictures
to form a difference data signal. The difference data signal is
orthogonally transformed into blocks of coefficient data which
are quantized, variable length encoded and transmitted as encoded
data.

15   At the encoder 18, the quantized data are dequantized,
inverse orthogonally transformed, and stored as the reference
pictures. The predictive encoding applies the motion vector(s)
obtained for the current picture to the reference picture(s) to
produce a prediction picture which is subtracted from the current

20   picture to yield the difference data.

The elements of the encoder 18 will now be explained in
detail.

Picture data for encoding is supplied macro-block by
macro-block to the input terminal 49 and thence to a motion

25   vector detection circuit 50 which is operative to process the

picture data of respective frames as I-pictures, P-pictures or as B-pictures, in accordance with a predetermined sequence for each group of pictures, as shown for example, in Figs. 2A, 2B. The circuit 50 applies the picture data of the current frame to a

5   frame memory 51 having frame memories 51a, 51b, 51c used for storing a temporally preceding picture, the current picture and a temporally succeeding picture, respectively.

More specifically, the frames F1, F2, F3 are stored in the memories 51a, 51b, 51c, respectively. Then the picture

10   stored in memory 51c is transferred to memory 51a. The frames F4, F5 are stored in the memories 51b, 51c, respectively. The operations of transferring the picture in memory 51c to memory 51a and storing the next two pictures in memories 51b, 51c are repeated for the remaining pictures in the group of pictures.

15   After the pictures are read into the memory and temporarily stored, they are read out and supplied to a prediction mode changeover circuit 52 which is adapted to process the current picture for one of frame based and field based predictive encoding. After processing the first frame picture

20   data in a group of pictures as an I-picture and before processing the second frame picture as a B-picture, the motion vector detection circuit 50 processes the third frame P-picture. The processing sequence is different from the sequence in which the pictures are supplied because the B-picture may involve backward

prediction, so subsequent decoding may require that the P-picture temporally succeeding the B-picture have been previously decoded.

The motion vector detection circuit 50 calculates as an estimated value for intra-coding for each macro-block, the sum of

5 absolute values of prediction errors for the frame prediction mode for each macro-block and the sum of absolute values of prediction errors for the field prediction mode for each macro-block and supplies these sums to the prediction decision circuit 54 which compares these sums and selects frame prediction mode or

10 field prediction mode in accordance with the smallest of these values and provides the selected mode to the prediction mode changeover circuit 52.

If the frame prediction mode is selected, the prediction mode changeover circuit 52 outputs the four luminance

15 blocks Y1 to Y4 and the two chrominance or color difference blocks Cb, Cr of each macro-block received from the motion vector detection circuit 50 without processing. As shown in Fig. 7A, odd or first field line data, indicated by solid lines, and even or second field line data, indicated by dashed lines, alternate

20 in each luminance and color difference block as received from the motion vector detection circuit 50. In Fig. 7A, a indicates units for motion compensation. In the frame prediction mode, motion compensation is performed with four luminance blocks (macro-blocks) as a unit and a single motion vector is associated

25 with the four luminance blocks Y1 to Y4.

If the field prediction mode is selected, the
prediction mode changeover circuit 52 processes the signals
received from the motion vector detection circuit 50 so that each
of the four luminance blocks comprises data from a single field

5   and the two color difference blocks have non-interlaced odd and
even field data. Specifically, as shown in Fig. 7B, the
luminance blocks Y1 and Y2 have odd-field data and the luminance
blocks Y3 and Y4 have even-field data, while the upper halves of
the color difference blocks Cb, Cr represent odd field color

10   difference data for the luminance blocks Y1 and Y2 and the lower
halves of the color difference blocks Cb, Cr represent even field
color difference data for the luminance blocks Y3 and Y4. In
Fig. 7B, b indicates units for motion compensation. In the field
prediction mode, motion compensation is performed separately for

15   the odd-field blocks and even-field blocks so that one motion
vector is associated with the two luminance blocks Y1 and Y2 and
another motion vector is associated with the two luminance blocks
Y3 and Y4.

        The prediction mode changeover circuit 52 supplies the

20   current picture, as processed for frame based or field based
predictive encoding, to arithmetic unit 53 of Fig. 6. The
arithmetic unit 53 functions to perform one of intra-picture
prediction, forward prediction, backward prediction or bi-
directional prediction. A prediction decision circuit 54 is

25   adapted to select the best type of prediction in dependence upon

the prediction error signals associated with the current picture signals.

The motion vector detection circuit 50 calculates, for the current picture, the sum of absolute values of the differences between each Aij and the average value of the Aij in each macro-block $\Sigma|Aij - (average\ of\ Aij)|$ and supplies the sum as an estimated value for intra-coding to the prediction decision circuit 54.

The motion vector detection circuit 50 calculates the sum of absolute values (or sum of squares) of the difference (Aij - Bij) between signals Aij of the macro-blocks of the current picture, and signals Bij of the macro-blocks of the prediction picture $\Sigma|Aij - Bij|$ in each of frame prediction mode and field prediction mode. As explained above, the motion vector(s) for the current picture are applied to the reference picture(s) to generate the prediction picture. When the reference picture temporally precedes the current picture, the quantity $\Sigma|Aij - Bij|$ is referred to as a forward prediction error signal, and when the reference picture temporally succeeds the current picture, the quantity $\Sigma|Aij - Bij|$ is referred to as a backward prediction error signal. When the prediction picture is the mean of a temporally preceding and a temporally succeeding reference picture, as motion-compensated, the quantity $\Sigma|Aij - Bij|$ is referred to as a bi-directional prediction error signal.

The circuit 50 supplies the forward frame prediction, the forward field prediction, the backward frame prediction, the backward field prediction, the bi-directional frame prediction and the bi-directional field prediction error signals to the

5   prediction decision circuit 54.

The prediction decision circuit 54 selects one of intra-coding, forward inter-picture prediction, backward inter-picture prediction or bi-directional inter-picture prediction and one of frame and field prediction mode in accordance with the

10   smallest of the estimated value for intra-coding and the forward frame, the forward field, the backward frame, the backward field, the bi-directional frame and the bi-directional field prediction error signals. The arithmetic unit 53 predictively encodes the current picture, as processed by the frame or field changeover

15   circuit 52, in accordance with the prediction mode selected by the prediction decision circuit 54.

The motion vector detection circuit 50 serves to calculate and supply the motion vector(s) associated with the selected prediction mode to a variable length encoding circuit 58

20   and a motion compensation circuit 64, explained later.

The sums of the absolute values of the inter-frame differences (prediction errors) on the macro-block basis are supplied from the motion vector detection circuit 50 to the prediction mode changeover circuit 52 and to the prediction

25   decision circuit 54, in the manner as described above.

The arithmetic unit 53 supplies predictively encoded data, also referred to as difference data, for the current picture to a DCT mode changeover circuit 55 which is adapted to process the current picture for one of frame based and field based orthogonal transformation.

The DCT changeover circuit 55 functions to compare the encoding efficiency when the DCT operations for the macro-blocks in a picture are performed with the odd field data alternating with the even field data, that is, for frame based orthogonal transformation, as shown in Fig. 8A, with the encoding efficiency when the DCT operations for the macro-blocks in a picture are performed with the odd field data separated from the even field data, that is, for field based orthogonal transformation, as shown in Fig. 8B. The circuit 55 functions to select the mode with the higher encoding efficiency.

To evaluate the encoding efficiency for frame based orthogonal transformation, the DCT mode changeover circuit 55 places the luminance macro-block data into interlaced form, as shown in Fig. 8A, and calculates the differences between the odd field line signals and even field line signals vertically adjacent to each other, and finds the sum of absolute values of the differences EFM, or the sum of squared values of the differences.

$$EFM = \sum_{j=1}^{16} \sum_{i=1}^{16} | o(i,j) - e(i,j) | + \sum_{j=1}^{16} \sum_{i=1}^{15} | e(i,j) - o(i+1,j) | \quad Eq.1$$

To evaluate the encoding efficiency for field based orthogonal transformation, the DCT mode changeover circuit 55 places the luminance macro-block data into non-interlaced form, as shown in Fig. 8B, and calculates the differences between vertically adjacent odd field line signals and the differences between vertically adjacent even field line signals, and finds the sum of absolute values of the differences EFD, or the sum of squared values of the differences.

$$EFD = \sum_{j=1}^{16} \sum_{i=1}^{15} (| o(i,j) - o(i+1,j) | + | e(i,j) - e(i+1,j) |) \quad Eq.2$$

The DCT changeover circuit 55 compares the difference between the frame based and field based sums of the absolute values with a predetermined threshold and selects frame based DCT transformation if the difference EFM - EFD is less than the predetermined threshold.

If the frame prediction mode is selected in the prediction mode changeover circuit 52, the probability is high that the frame DCT mode will be selected in the DCT mode changeover circuit 55. If the field prediction mode is selected

in the prediction mode changeover circuit 52, the probability is high that the field DCT mode will be selected in the DCT mode changeover circuit 55. However, since this is not necessarily the case, the prediction mode changeover circuit 52 sets the mode

5   which will give the least value of the sum of the absolute values of prediction errors, while the DCT mode changeover circuit 55 sets the mode which will give the optimum orthogonal transformation encoding efficiency.

If frame based orthogonal transformation mode, also

10   referred to as frame DCT mode, is selected, the DCT mode changeover circuit 55 functions to ensure that the four luminance blocks Y1 to Y4 and two color difference blocks Cb, Cr represent alternating or interlaced odd and even field lines, as shown in Fig. 8A.

15   If field based orthogonal transformation mode, also referred to as field DCT mode, is selected, the DCT mode changeover circuit 55 functions to ensure that each of the luminance blocks represents only one field, and that each of the color difference blocks has segregated or non-interlaced odd and

20   even field lines, as shown in Fig. 8B.

The DCT mode changeover circuit 55 functions to output the data having the configuration associated with the selected DCT mode, and to output a DCT flag indicating the selected DCT mode to the variable length encoding circuit 58 and the motion

25   compensation circuit 64.

The DCT mode changeover circuit 55 supplies appropriately configured difference picture data to a DCT circuit 56 shown in Fig. 6 which is operative to orthogonally transform it using a discrete cosine transformation into DCT coefficients,

5   and to supply the DCT coefficient data to a quantization circuit 57 that functions to quantize the coefficient data with quantization steps selected in accordance with the volume of data stored in a transmission buffer 59 and to supply quantized data to a variable length encoding circuit 58.

10   The variable length encoding circuit 58 is also supplied with the quantization step or scale data from the quantization circuit 57, prediction mode data from the prediction decision circuit 54, that is data indicating which of the intra-picture prediction, forward prediction, backward prediction or

15   bi-directional prediction is used, and motion vector data from the motion vector detection circuit 50. The encoding circuit 58 also receives prediction flag data from the prediction decision circuit 54 comprising a flag indicating which of the frame prediction mode or the field prediction mode is used, and

20   prediction flag data from the DCT mode changeover circuit 55 comprising a flag indicating which of the frame DCT mode or the field DCT mode is used. This information is placed into the header portion of the encoded data stream.

The variable length encoding circuit 58 serves to

25   encode the quantized data and the header information using a

variable length code such as a Huffman code, in accordance with the quantization step data supplied from the quantization circuit 57, and to output the resulting data to a transmission buffer 59.

The quantized data and quantization step are also

5   supplied to a dequantization circuit 60 which serves to dequantize the quantized data using the quantization step, and to supply the recovered DCT coefficient data to an inverse DCT circuit 61 that functions to inverse transform the DCT coefficient data to produce recovered difference data and to

10   supply the recovered difference data to an arithmetic unit 62.

The arithmetic unit 62 combines the recovered difference data with a previously encoded and decoded reference picture, as motion compensated, to produce decoded data for a reconstructed picture which will be used as a reference picture

15   and which is read into one of two frame memories 63a, 63b. The memories 63a, 63b are adapted to read out the reference picture data stored therein to a motion compensation circuit 64 that uses the motion vectors from the motion vector detection circuit 50 to produce a prediction picture from the reference picture.

20   Specifically, the circuit 50 uses the motion vector to alter the readout address of the reference picture from the memory 63a or 63b.

For a group of pictures, after the first frame I-picture data and the third frame P-picture data are stored in the

25   forward and backward prediction picture memories or units 63a,

63b, respectively, the second frame B-picture data is processed

by the motion vector detection circuit 50. The prediction

decision circuit 54 selects the frame or field prediction mode,

while setting the prediction mode to one of intra-frame

5   prediction mode, forward prediction mode, backward prediction

mode and bi-directional prediction mode in correspondence with

the sum of absolute values of predictive errors by macro-block.

Since a reconstructed B-picture is not used as a

reference picture for other pictures, it is not stored in the

10   frame memory 63.

It will be appreciated that the frame memory 63 has its

forward and backward prediction picture units 63a, 63b bank-

exchanged as needed so that a picture stored in one of the units

63a or 63b can be outputted as either a forward or a backward

15   prediction picture.

The motion compensation circuit 64 functions to supply

the motion compensated data as a prediction picture to the

arithmetic unit 62 and to the arithmetic unit 53 which subtracts

the prediction picture from the P-picture or the B-picture

20   currently being predictively encoded.

More specifically, when the motion vector detection

circuit 50 receives picture data for an I-picture from the

forward original picture unit 51a, the prediction decision

circuit 54 selects the intra-frame prediction mode and sets a

25   switch 53d of the arithmetic unit 53 to an input contact a. This

causes the I-picture data to be inputted directly to the DCT mode

changeover circuit 55. In this case, no prediction picture is

expected from the motion compensation circuit 64. The I-picture

data is also supplied to the forward prediction picture unit 63a.

5   When the forward prediction mode is selected by the

prediction decision circuit 54, the circuit 54 also sets the

switch 53d to an input contact b which causes the arithmetic unit

53a to subtract the prediction picture, produced by the motion

compensation circuit 64, from the picture read out from the

10   memory 51, for each macro-block on a pixel by pixel basis, to

produce difference data. The P-picture, after encoding and local

decoding, is supplied to one of the units 63a, 63b. For example,

if the P-picture immediately follows an I-picture, then the P-

picture is stored in the backward prediction picture unit 63b.

15   For forward predictive encoding, the prediction picture

is a reference I-picture or P-picture read out from the forward

prediction picture unit 63a of the frame memory 63 and motion-

compensated by the motion compensation circuit 64 in accordance

with the motion vector outputted from the motion vector detection

20   circuit 50. More specifically, for each macro-block, the motion

compensation circuit 64 shifts the readout address of the forward

prediction picture unit 63a in an amount corresponding to the

motion vector currently output by the motion vector detection

circuit 50.

When the backward prediction mode is selected by the prediction decision circuit 54, the circuit 54 also sets the switch 53d to an input contact c which causes the arithmetic unit 53b to subtract the prediction picture, produced by the motion

5   compensation circuit 64, from the picture read out from the memory 51, on a pixel by pixel basis, to produce difference data.

For backward predictive encoding, the prediction picture is a P-picture read out from the backward prediction picture unit 63b of the frame memory 63 and motion-compensated by

10   the motion compensation circuit 64 in accordance with the motion vector outputted from the motion vector detection circuit 50. More specifically, for each macro-block, the motion compensation circuit 64 shifts the readout address of the backward prediction picture unit 63b in an amount corresponding to the motion vector

15   currently output by the motion vector detection circuit 50.

When the bi-directional prediction mode is selected by the prediction decision circuit 54, the circuit 54 sets the switch 53d to an input contact d which causes the arithmetic unit 53c to subtract a prediction picture from the picture read out

20   from the memory 51, on a pixel by pixel basis, to produce difference data. The prediction picture is the mean value of a forward prediction picture and a backward prediction picture.

In the case of bi-directional prediction, the picture stored in the forward prediction picture unit 63a, and the

25   picture stored in the backward prediction picture unit 63b, are

read out and motion-compensated by the motion compensation circuit 64 in dependence upon the motion vectors outputted from the motion vector detection circuit 50. More specifically, for each macro-block, the motion compensation circuit 64 shifts the

5   readout address of the forward and backward prediction picture units 63a, 63b in an amount corresponding to the appropriate one of the motion vectors currently output by the motion vector detection circuit 50.

The transmission buffer 59 temporarily stores the data

10   supplied thereto, generates control data indicating the volume of data stored therein and supplies the control data to the quantization circuit 57. When the volume of data stored in the transmission buffer 59 reaches a predetermined upper limit value, the control data from the transmission buffer 59 causes the

15   quantization scale of the quantization circuit 57 to increase so as to decrease the volume of the quantized data. Similarly, when the volume of data stored in the transmission buffer 59 reaches a predetermined lower limit value, the control data from the transmission buffer 59 causes the quantization scale of the

20   quantization circuit 57 to decrease so as to increase the volume of the quantized data. In this manner, the transmission buffer 59 prevents the data supplied thereto from overflowing or underflowing its capacity. The data stored in the transmission buffer 59 are read out at a predetermined timing to an output

terminal 69 and thence to a transmission channel for recording
on, for example, the recording medium 3.

Although the foregoing description has been made with
reference mainly to the luminance blocks, the color difference
5   blocks are similarly processed and transmitted using the motion
vector which corresponds to the motion vector of the luminance
block halved in both the vertical and horizontal directions.

Fig. 9 illustrates the decoder 31 shown in Fig. 4.

The reproduced encoded picture data transmitted from
10   the recording medium 3 is applied to a reception circuit, not
shown, or to an input terminal 80 which applies the encoded
picture data to a reception buffer 81 that serves to temporarily
store the encoded picture data and to supply this data to a
variable length decoding circuit 82 of a decoding circuit 90.

15   The variable length decoding circuit 82 functions to
variable length decode the encoded data, to output the recovered
motion vector, prediction mode data, prediction flags and DCT
flags to the motion compensation circuit 87, and to output the
quantization step data and variable length decoded picture data,
20   including the predictive mode, the motion vector, the predictive
flag, the DCT flag and the quantized picture data for each macro-
block, to an inverse quantization circuit 83.

The inverse quantization circuit 83 is adapted to
dequantize the picture data supplied from the variable length
25   decoding circuit 82 in accordance with the quantization step data

supplied from the variable length decoding circuit 82 and to

output the thus recovered coefficient data to an inverse

transformation IDCT circuit 84.

The IDCT circuit 84 is adapted to perform an inverse

5   transformation on the recovered coefficient data to produce

recovered difference data, and to supply the recovered difference

data to an arithmetic unit 85.

If the recovered difference data supplied from the IDCT

circuit 84 represents an I-picture, the arithmetic unit 85 does

10   not process the data and simply supplies it through an output

terminal 91 to the format converting circuit 32 shown in Fig. 4,

and to a forward prediction picture unit 86a of a frame memory

86.

If the recovered difference data supplied from the IDCT

15   circuit 84 represents a macro-block of a P-picture produced in

the forward prediction mode, then the reference picture data of

the preceding frame, as stored in the forward prediction picture

memory 86a of the frame memory 86, is read and motion-compensated

by a motion compensation circuit 87 in dependence upon the motion

20   vector outputted from the variable length decoding circuit 82 to

generate a prediction picture. Specifically, the motion

compensation circuit 87 uses the motion vector to alter the read

out address supplied to the memory 86a. The arithmetic unit 85

adds the prediction picture to the recovered difference data to

25   produce a decoded or reconstructed picture which is stored in a

backward prediction picture memory 86b of the frame memory 86.

The decoded P-picture is retained in the decoder 31, and output

after the next B-picture is decoded and output, so as to restore

the pictures to the order in which they were supplied to the

5   encoder 18 of Fig. 4.

        Even if the macro-block of the P-picture was encoded as

intra-coded mode data, the decoded P-picture is directly stored

in the backward prediction picture unit 86b, without being output

to the output terminal 91 by the arithmetic unit 85.

10   If the recovered difference data supplied from the IDCT

circuit 84 represents a macro-block of a B-picture encoded in the

intra-coding mode, as determined from the prediction mode

supplied from the variable length decoding circuit 82 to the

motion compensation circuit 87, a prediction picture is not

15   generated.

        If the recovered difference data supplied from the IDCT

circuit 84 represents a macro-block of a B-picture encoded in the

forward prediction mode, as determined from the prediction mode

supplied from the variable length decoding circuit 82 to the

20   motion compensation circuit 87, the data stored in the forward

prediction picture unit 86a of the frame memory 86 is read out

and motion compensated by the motion compensation circuit 87

using the motion vector supplied from the variable length

decoding circuit 82 to form the prediction picture.   The

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arithmetic unit 85 sums the recovered difference data with the prediction picture to form the recovered B-picture.

If the recovered difference data supplied from the IDCT circuit 84 represents a macro-block of a B-picture encoded in the

5   backward prediction mode, as determined from the prediction mode supplied from the variable length decoding circuit 82 to the motion compensation circuit 87, the data stored in the backward prediction picture unit 86b is read out and motion compensated by the motion compensation circuit 87 using the motion vector

10   supplied from the variable length decoding circuit 82 to form the prediction picture. The arithmetic unit 85 sums the recovered difference data with the prediction picture to form the recovered B-picture.

If the recovered difference data supplied from the IDCT

15   circuit 84 represents a macro-block of a B-picture encoded in the bi-directional prediction mode, as determined from the prediction mode supplied from the variable length decoding circuit 82 to the motion compensation circuit 87, the data stored in both the forward and backward prediction picture memories 86a, 86b are

20   read out and respectively motion compensated by the motion compensation circuit 87 using the motion vectors supplied from the variable length decoding circuit 82, then averaged to form the prediction picture. The arithmetic unit 85 sums the recovered difference data with the prediction picture to form the

25   recovered B-picture.

The recovered B-picture is supplied via the output terminal 91 to the format converting circuit 32. However, since the B-picture is not utilized for generating a prediction picture for other pictures, it is not stored in the frame memory 86.

5   After outputting of the B-picture, picture data of the P-picture stored in the backward prediction picture unit 86b is read and supplied via the motion compensation circuit 87 to the arithmetic unit 85. Motion compensation is not performed at this time.

10   The counterpart circuits to the prediction mode changeover circuit 52 and the DCT mode changeover circuit 55 in the encoder 18 of Fig. 6 are not shown in the decoder 31. The processing to be performed by these circuits, that is, the processing for restoring the configuration in which odd-field
15   line signals and even-field line signals are separated from each other to the configuration in which odd and even-field line signals alternate with each other, is performed by the motion compensation circuit 87.

The processing of the luminance signals has been
20   explained in the foregoing. As will be appreciated by one of ordinary skill in the art, the processing of the color difference signals is carried out in a similar manner. However, the motion vector employed in such case is the motion vector for luminance signals which is halved in both the vertical and horizontal
25   directions.

Fig. 10 shows the signal to noise ratio (SNR) for pictures transmitted using the above-described technique. As can be seen, the best quality transmission is obtained for I-pictures, good quality transmission is obtained for P-pictures, and the poorest quality transmission is obtained for B-pictures. Thus, if the transmission path has adequate capacity, it is preferable to transmit a picture as an I-picture.

If all pictures cannot be transmitted as I-pictures, it is better to transmit a series of pictures as shown in Fig. 10, rather than in a format in which one average picture quality is used for all pictures. The technique shown in Fig. 10 takes advantage of the human visual sense characteristic of perceiving a series of changing picture quality, as shown in Fig. 10, as of higher quality than a series of unchanging picture quality, for a predetermined transmission rate.

Accordingly, in the configuration of Fig. 6, transmission rate control is carried out by the quantizer 57 in order to attain the picture quality perceived as better.

To dub pictures, two coder-decoder (codec) units are used in series. However, the picture quality obtained from the second codec is substantially worse than the picture quality obtained from the first codec, as explained below.

Fig. 11 shows a configuration representing two codecs connected by an analog connection, namely, coder 201, decoder 202, coder 203 and decoder 204, connected in series.

In Fig. 11, an analog video signal is supplied to an input terminal 200 as an input signal a. The input terminal 200 functions to apply the analog video signal to an A/D converter 211 of coder 201. The converter 211 is adapted to convert the

5   analog video signal to a digital video signal, and to apply the digital video signal to coding circuit 212 that serves to encode this signal as previously described to produce a coded digital video signal.

The coded digital video signal from coding circuit 212

10 of coder 201 is supplied to a decoding circuit 213 of decoder 202 which is adapted to decode the coded digital video signal and to apply the decoded video signal to D/A converter 214.

The analog video signal produced by D/A converter of decoder 202 is supplied as an output signal b to the coder 203,

15 which functions in a similar manner as the coder 201.

The digital video signal produced by the coder 203 is supplied to decoder 204 which functions in a similar manner as the decoder 202. The decoder 204 delivers an analog video signal as an output signal c to a terminal 205, which may transmit the

20 signal c to another coder (not shown) and so on.

Fig. 12 shows the SNR of the output signals b, c shown in Fig. 11. The SNR of the output signal c is seen to be substantially worse than the SNR of the output signal b.

The deterioration in picture quality results from a

25 mismatch between the picture type applied in the first codec and

the picture type applied in the second codec. Namely, if a

picture coded as a B picture in the first coder/decoder pair is

coded as, e.g., P picture in the second coder/decoder pair, a

great deterioration of picture quality results because the

5   picture quality changes as a function of the picture type.

Since the deterioration in picture quality results

from the mismatch between picture types of respective stages of

codecs, such deterioration similarly takes place when digital

connections are used between respective codecs.

10   Fig. 13 shows a configuration representing two codecs

connected by a digital connection, namely, coder 302, decoder

303, coder 304 and decoder 305, connected in series.

An analog video signal is supplied to terminal 300,

which supplies the analog video signal as an input signal a to

15   A/D converter 301 that serves to digitize the signal a, and to

apply the digital signal to a digital interface 311 of coder 302.

The digital interface 311 applies the signal supplied thereto to

a coding circuit 312 which encodes or compresses the digital

video data to an encoded digital video bit stream.

20   The encoded digital video signal from the coding

circuit 312 is supplied to decoding circuit 313 of decoder 303

that decodes the signal supplied thereto, and applies the decoded

signal to digital interface 314. The interface 314 functions to

output the decoded signal as an output signal b.

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The output signal b is supplied to coder 304 which functions in a similar manner as coder 302 to produce a coded signal that is applied to decoder 305 which functions in a similar manner as decoder 303. The digital signal output from the decoder 303 is supplied to a D/A converter that serves to convert the signal supplied thereto to an analog video signal and to supply the analog video signal as an output signal c to output terminal 307.

Fig. 12 also generally represents the SNR of the output signals b, c shown in Fig. 13.

OBJECTS AND SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a method and apparatus for encoding and decoding picture signals which avoid the aforementioned disadvantages of the prior art.

Another object of the present invention is to provide a method and apparatus for transmitting and receiving picture signals in serial stages which minimizes the deterioration in picture quality at each stage.

Yet another object of the present invention is to match the type of coding applied to pictures of a picture signal in serial processing stages, each stage comprising coding and decoding.

In accordance with one embodiment of the present invention, apparatus and method for processing a digital picture

signal operate by receiving a digital picture signal which has picture type data included in a data identification area of the digital picture signal and which indicates one of intrapicture coding, predictive coding and bidirectionally predictive coding

5   for respective pictures represented by the digital picture signal. The picture signal is encoded as a function of the picture type data to produce an encoded picture signal.

In accordance with another embodiment of the present invention, apparatus and method for processing an encoded digital

10   picture signal operate by decoding the encoded digital picture signal so as to produce picture type data which represents the type of encoding of the encoded digital picture signal and to produce a decoded digital picture signal. The picture type data is added to a data identification area of the decoded digital

15   picture signal to produce an output signal.

The above, and other objects, features and advantages of the present invention will be apparent from the following detailed description of the preferred embodiments of the present invention when read in conjunction with the accompanying drawings

20   in which corresponding parts are identified by the same reference numeral.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B are pictures illustrating inter-frame correlation;

Figs. 2A and 2B are diagrams illustrating types of pictures used in predictive encoding;

Fig. 3 is a diagram illustrating how picture signals are converted into encoded data for transmission;

5   Fig. 4 is a block diagram showing a conventional device for encoding and decoding picture signals;

Fig. 5 is a diagram referred to in explaining the operation of the format converting circuit shown in Fig. 4;

Fig. 6 is a block diagram showing the encoder of the

10   device shown in Fig.4;

Fig. 7 is a chart referred to in explaining the predictive encoding operation of the encoder shown in Fig. 6;

Fig. 8 is a chart referred to in explaining the orthogonal transformation operation of the encoder shown in Fig.

15   6;

Fig. 9 is a block diagram showing the decoder of the device shown in Fig. 4;

Fig. 10 is a graph showing picture quality as a function of picture type in a transmitted signal;

20   Fig. 11 is a block diagram showing two conventional video codecs connected in series using an analog connection;

Fig. 12 is a graph showing picture quality of the signals output by the codecs of Fig. 11;

Fig. 13 is a block diagram showing two conventional

25   video codecs connected in series using a digital connection;

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Fig. 14 is a block diagram showing two video codecs according to the present invention connected in series using an analog connection;

Fig. 15 is a graph showing picture quality of the signals output by the codecs of Fig. 14;

Fig. 16 is a block diagram showing two video codecs according to the present invention connected in series using a digital connection;

Figs. 17A, 17B and 17C illustrate the data structure of a decoded digital video signal;

Figs. 18A, 18B and 18C are diagrams illustrating various encoding structures of groups of pictures;

Fig. 19 is a block diagram showing a coder circuit according to the present invention; and

Fig. 20 is a block diagram showing a decoding circuit according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention comprises a picture type identifier which is included with the picture signal at all times, namely, when the signal is encoded and when the signal is decoded. The picture type indicates one of intra-picture coding (an I-picture), predictive coding (a P-picture) and bi-directionally predictive coding (a B-picture). An I-picture includes macro-blocks encoded by only intra-coding. A P-picture includes macro-blocks encoded by intra-coding and/or macroblocks

encoded by forward predictive coding. A B-picture includes macro-blocks encoded by intra-coding and/or macroblocks encoded by forward predictive coding and/or macroblocks encoded by backward predictive coding and/or macroblocks encoded by bi-

5   directionally predictive coding.

Initially, each picture of a picture signal is encoded as a function of a respective picture type, then appropriately decoded. The decoded picture signal includes the respective picture types, preferably in the vertical blanking interval of

10   each decoded picture. The decoded picture signal may be further processed by, for example, dubbing.

When the pictures of the decoded picture signal are again encoded, the re-encoding is a function of the picture type included in the decoded picture signal. The re-encoded signal

15   includes the picture type. Subsequent decoding of the re-encoded picture is a function of the picture type. Each picture of the re-decoded picture signal includes its respective picture type.

Thus, the present invention matches the type of predictive coding applied to pictures in a picture signal by

20   serially arranged coders which process the picture signal.

The present invention promotes optimum picture quality. A picture, previously encoded as an I-picture, P-picture or B-picture is again encoded as an I-picture, P-picture or B-picture, respectively. Also, encoding of a picture, previously encoded as

25   a B-picture, as an I-picture or a P-picture is prevented. Thus,

deterioration in signal quality after plural coding and decoding operations is minimized.

Referring now to the drawings, and in particular to Fig. 14, there are illustrated coding and decoding units (codecs)

5   according to the present invention having a serial analog connection therebetween. A first codec comprises coder 120 and decoder 121, while a second codec comprises coder 122 and decoder 123. It will be appreciated by one of ordinary skill in the art that additional codecs may be serially connected to those shown

10   in Fig. 14.

In Fig. 14, an analog video signal is supplied to an input terminal 100 as an input signal a, and a picture type signal is supplied to an input terminal 108. The picture type indicates one of intra-picture coding (an I-picture), predictive

15   coding (a P-picture) and bi-directionally predictive coding (a B-picture).

The input terminals 100, 108 function to apply the analog video signal and the picture type signal, respectively, to an A/D converter 101 and a coding circuit 102, respectively, of

20   coder 120. The converter 101 is adapted to convert the analog video signal to a digital video signal, and to apply the digital video signal to the coding circuit 102.

The coding circuit 102 serves to encode the digital video signal as a function of the picture type signal to produce

25   a coded digital video signal which includes, for each encoded

picture, its picture type as identified by the picture type signal. More specifically, if the picture type for a picture indicates intra-picture coding, then the coding circuit 102 codes the picture as an I-picture. If the picture type for a picture

5   indicates predictive coding, then the coding circuit 102 codes the picture as a P-picture. If the picture type for a picture indicates bi-directionally predictive coding, then the coding circuit 102 codes the picture as a B-picture.

The coding unit 120 may alternatively have the

10   structure shown in Fig. 6, in which coding is performed without reference to an externally supplied picture type. As used herein, an externally supplied picture type means a picture type supplied from generally the same source as supplies the digital video signal, rather than from a separate source as is shown in

15   Fig. 6, namely, the picture type input device 65.

The coded digital video signal from coding circuit 102 of Fig. 14 is supplied to a decoding circuit 103 of decoder 121 which is adapted to decode the coded digital video signal as a function of the picture type included in the encoded signal and

20   to apply the decoded video signal to D/A converter 104. The decoding circuit 103 is further adapted to apply the picture type decoded from the coded digital video signal to a multiplexer 105.

The multiplexer 105 is operative to multiplex the picture type information with the decoded video signal to produce

25   a multiplexed analog video signal as an output signal b in which

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the picture type information is contained in the decoded video signal. Preferably, the multiplexer 105 inserts the picture type for a picture of the decoded video signal into the vertical blanking interval of the picture. As mentioned, a picture may be either a frame or a field of the video signal.

The output signal b is supplied from the multiplexer 105 to a separating circuit 106 of the coder 122. The separating circuit is operative to separate or demultiplex the analog video signal and the picture type information from the output signal b, to supply the separated analog video signal to an A/D converter 107, and to supply the separated picture type information to a coding circuit 108. The converter 107 is adapted to convert the separated analog video signal to a digital video signal, and to apply the digital video signal to the coding circuit 108.

The coding circuit 108 serves to encode the digital video signal as a function of the separated picture type to produce a re-coded digital video signal which includes, for each re-encoded picture, its picture type as identified by the separated picture type signal.

The re-coded digital video signal from the coding circuit 108 is supplied to the decoder 123, which operates in a similar manner as the decoder 121.

Decoding circuit 110 of decoder 123 decodes the re-coded digital video signal to produce a re-decoded digital video signal and a corresponding picture type signal. The re-decoded

digital video signal is converted to an analog signal by D/A converter 109, and applied to a multiplexer 111 which multiplexes the analog video signal with the picture type signal from decoding circuit 110 to produce a multiplexed analog video signal

5   as an output signal c. Preferably, the multiplexer 111 inserts the picture type for a picture into the vertical blanking interval of the picture. The multiplexer 111 applies its output signal c to an output terminal 119.

Due to the inclusion of the picture type identifier in

10   the signals b and c, the codecs of Fig. 14 process respective pictures of the video signals b and c in the same manner, that is, as the same one of an I-picture, a P-picture or a B-picture.

Fig. 15 shows the SNR of the output signals b, c shown in Fig. 14. The SNR of the output signal c is seen to be only

15   slightly worse than the SNR of the output signal b.

That is, since the type of predictive coding applied to each picture is the same in each of the serially arranged codecs, the deterioration in picture quality at each codec is minimized even when the picture quality changes from picture to picture due

20   to the type of predictive coding employed from picture to picture.

Fig. 16 shows codecs according to the present invention having a serial digital connection therebetween. A first codec comprises coder 142 and decoder 143, while a second codec

25   comprises coder 144 and decoder 145.

In Fig. 16, an analog video signal is supplied to an input terminal 140 as an input signal a, and a picture type signal is supplied to an input terminal 148. The input terminals 140, 148 function to apply the analog video signal and the

5 picture type signal, respectively, to an A/D converter 141 and a coding circuit 152 of coder 142, respectively. The converter 141 is adapted to convert the analog video signal to a digital video signal, and to apply the digital video signal to a digital interface 151 of coder 142.

10 The coding circuit 152 serves to encode the digital video signal as a function of the picture type signal to produce a coded digital video signal which includes, for each encoded picture, its picture type as identified by the picture type signal. More specifically, if the picture type for a picture

15 indicates intra-picture coding, then the coding circuit 152 codes the picture as an I-picture. If the picture type for a picture indicates predictive coding, then the coding circuit 152 codes the picture as a P-picture. If the picture type for a picture indicates bi-directionally predictive coding, then the coding

20 circuit 152 codes the picture as a B-picture.

The coding unit 120 may alternatively have the structure shown in Fig. 6, in which coding is performed without reference to an externally supplied picture type.

The coded digital video signal from coding circuit 152

25 is supplied to a decoding circuit 153 of decoder 143 which is

adapted to decode the coded digital video signal as a function of
the picture type included in the encoded signal and to apply the
decoded video signal to a digital interface 154. The decoding
circuit 153 is further adapted to apply the picture type decoded
5   from the coded digital video signal to a multiplexer 155.

The multiplexer 155 is operative to multiplex the
picture type information with the decoded video signal to produce
a multiplexed digital video signal as an output signal b in which
the picture type information is contained in the decoded video
10   signal. Preferably, multiplexer 155 multiplexes the picture type
for a picture of the decoded video signal as a flag in the
respective picture.

In a preferred embodiment of the present invention, the
picture type information is inserted (or multiplexed) into the
15   decoded video signal at a location therein which precedes the
actual video data that represents the video field or frame.
Figs. 17A, 17B and 17C illustrate the data structure of the
decoded (MPEG) video signal. Fig. 17A illustrates the data
structure of a decoded video signal having a serial digital
20   interface format as specified in the standard SMPTE - 259
(Society of Motion Picture & Television Engineers). As shown, a
frame consists of a first vertical blanking area VBK1, a first
optional blanking area OBK1 and a first active video area ACV1,
which constitutes the first field, followed by a second vertical
25   blanking area VBK2, a second optional blanking area OBK2 and a

second active video area ACV2, which constitutes the second

field. In the preferred embodiment, each of the vertical

blanking areas consists of 9 horizontal scanning lines, each of

the optional blanking areas consists of 10 horizontal scanning

5   lines, the first active video area consists of 244 horizontal

scanning lines and the second active video area consists of 243

horizontal scanning lines, for a total of 525 horizontal scanning

lines for a single frame.

Fig. 17B illustrates the data structure of a horizontal

10   scanning line. As shown, a horizontal scanning line includes an

end of active video (EAV) area followed by an ancillary (ANC)

area, a start of active video (SAV) area and a video area. The

ANC area, as shown in Fig. 17C, includes an ancillary data flag

(ADF) area followed by a data identification (DID) area, an

15   ancillary number data (DBN) area, an ancillary word data (DC)

area, an ancillary data (ANC DATA) area, and a check sum (CS)

area. Since the above-noted areas of a horizontal scanning line

of digital data are well-known in the art, their descriptions are

omitted herein except where necessary for an understanding of the

20   present invention.

In accordance with the present invention, the picture

type information is inserted into the DID area of the ANC area of

each of the horizontal scanning lines in the first and second

vertical blanking areas. However, the picture type information

25   also may be inserted into the DID area of the ANC area of other

horizontal scanning lines of the decoded video signal, although these DID areas may be used for transmitting other types of data. For example, the DID areas in horizontal lines of non-vertical blanking areas may include other formatting information.

5   The picture type information (or picture type data) may identify the type of encoding of the picture (e.g., intra-picture coding, predictive coding, and bi-directionally predictive coding) in various ways. Figs. 18A to 18C illustrate one method in which the type of encoding is identified by the structure of

10   the group of pictures (GOP). As shown, the structure of a group of pictures (GOP) may be identified by the minimum number of frames "M" between I and P pictures, between P and P pictures, and between I and I pictures, and the total number of frames "N" (pictures) in the group of pictures. For example, Fig. 18A

15   illustrates groups of pictures having an encoding structure of M=3 and N=9 in which there are 9 frames in each group and wherein there are 3 frames from each I or P frame to the respectively succeeding I or P frame. Similarly, Fig. 18B illustrates groups of pictures having an encoding structure of M=2 and N=2, and Fig.

20   18C illustrates groups of pictures having an encoding structure of M=1 and N=2.

        When the picture type data identifies the "M" and "N" numbers, the type of encoding for each picture can be determined by the location of a respective picture within the group of

25   pictures, and the location of a respective picture may be

identified in the picture type data either by identifying each picture's location within the group of pictures or by identifying only the first picture within the group of pictures. For example, when M=3 and N=9 for a group of frames in the decoded

5   video signal (Fig. 18A), the third frame in that group is identified as a decoded I-frame.

Returning to Fig. 16, the output signal b (the multiplexed decoded video signal) is supplied from the multiplexer 155 to a separating circuit 156 of the coder 144.

10   The separating circuit is operative to separate or demultiplex the digital video signal and the picture type data from the output signal b, to supply the separated digital video signal to a digital interface 157, and to supply the separated picture type data to a coding circuit 158. The interface 157 is adapted to

15   apply the separated digital video signal to the coding circuit 158.

The coding circuit 158 serves to encode the separated digital video signal as a function of the separated picture type to produce a re-coded digital video signal which includes, for

20   each re-encoded picture, its picture type as identified by the separated picture type signal.

The re-coded digital video signal from the coding circuit 158 is supplied to the decoder 145, which operates in a similar manner as the decoder 143.

Decoding circuit 160 of decoder 145 decodes the re-coded digital video signal to produce a re-decoded digital video signal and a corresponding picture type signal. The re-decoded digital video signal is supplied to a digital interface 159 and

5   thence to a multiplexer 161 which multiplexes the re-decoded digital video signal with the picture type signal from decoding circuit 160 to produce a multiplexed digital video signal. The multiplexer 161 multiplexes the picture type signal as a flag (e.g., in the DID area of the ANC area) in the re-decoded digital

10   video signal.

The multiplexer 161 supplies the multiplexed digital video signal to an A/D converter 146 which serves to convert the multiplexed digital video signal to an analog video signal also referred to as output signal c. The converter 146 applies the

15   output signal c to an output terminal 147.

Due to the inclusion of the picture type identifier in the signals b and c, the codecs of Fig. 16 process respective pictures of the video signals b and c in the same manner, that is, as the same one of an I-picture, a P-picture or a B-picture.

20   Consequently, the deterioration in picture quality at each codec is minimized even when the picture quality changes from picture to picture due to the type of predictive coding employed from picture to picture.

Fig. 19 shows the coding circuits of Figs. 14 and 16 in

25   more detail. In Fig. 19, elements similar to those in Fig. 6 are

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indicated by the same reference numerals, and detailed
explanations thereof are omitted.

In Fig. 19, a picture type signal is supplied to input
terminal 70 which serves to supply the picture type signal to

5   motion vector detector 450, predictive judging circuit 454 and
variable length coding circuit 458. The processing performed by
elements 450, 454 and 458 is similar to the processing performed
by elements 50, 54 and 58 of Fig. 6, except that the elements of
Fig. 19 perform in accordance with the picture type identified in

10   the external picture type signal which indicates the picture type
used in previous coding. The variable length coding circuit 458
includes the picture type based on the external picture type
signal as part of the header information.

Fig. 20 shows the decoding circuits of Figs. 14 and 16

15   in more detail. In Fig. 20, elements similar to those in Fig. 9
are indicated by the same reference numerals, and detailed
explanations thereof are omitted.

Variable length decoding circuit 482 of Fig. 20 is
similar to variable length decoding circuit 82 of Fig. 9, except

20   that circuit 482 applies the picture type separated from the
encoded signal not only to motion compensator 487, but also to
output terminal 92.

Although an illustrative embodiment of the present
invention, and various modifications thereof, have been described

25   in detail herein with reference to the accompanying drawings, it

is to be understood that the invention is not limited to this

precise embodiment and the described modifications, and that

various changes and further modifications may be effected therein

by one skilled in the art without departing from the scope or

5   spirit of the invention as defined in the appended claims.

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